Title
Predictors of Gains During Inpatient Rehabilitation in Patients with Stroke- A Review.

Journal
Critical reviews in physical and rehabilitation medicine, 25(3-4)

ISSN
0896-2960

Authors
Chang, Eric Y
Chang, Enoch H
Cragg, Samantha
et al.

Publication Date
2013

DOI
10.1615/critrevphysrehabilmed.2013008120

Critical Reviews™ in Physical and Rehabilitation Medicine, 25(3–4), 203–221 (2013)

Predictors of Gains During Inpatient Rehabilitation in Patients with Stroke: A Review

Eric Y. Chang,[1,2,] Enoch H. Chang,[2] Samantha Cragg,[2] & Steven C. Cramer[2,3,4]*

[1]Division of Pain Medicine, Department of Anesthesiology and Perioperative Care, Reeve-Irvine Research Center for Spinal Cord Injury, University of California, Irvine, CA; [2]Department of Physical Medicine and Rehabilitation, University of California, Irvine, CA; [3]Department of Neurology, University of California, Irvine, CA; [4]Department of Anatomy and Neurobiology, University of California, Irvine, CA

Drs. Chang and Chang contributed equally to the manuscript.

*Address all correspondence to: Eric Y Chang, Gillespie Building, Rm 3226A, 837 Health Science Road, Irvine CA 92687-1050; changey1@uci.edu

ABSTRACT: Stroke remains a major cause of disability. The cost of stroke rehabilitation is substantial. Understanding the factors that predict response to inpatient stroke rehabilitation may be useful, for example, to best individualize the content of therapy or maximize the efficiency with which resources are directed. This review evaluated the literature and found that numerous variables were associated with outcome after inpatient stroke rehabilitation. The strongest evidence exists for factors such as age, stroke subtype, nutritional status, and psychosocial factors such as living with family before the stroke or the presence of a caregiver. Functional status at admission, urinary incontinence, infection after stroke, and aphasia each can also affect prognosis. Strengths and weaknesses of cited studies were considered in an attempt to inform the design of future studies examining factors that predict response to inpatient rehabilitation after stroke.

KEY WORDS: stroke rehabilitation, predict

ABBREVIATIONS: ADLs, activities of daily living; **BDI,** Beck Depression Index; **BI,** Barthel Index; **CNS,** Canadian Neurological Scale; **FIM,** Functional Independence Measure; **FOOD,** Feed Or Ordinary Food; **ICH,** intracranial hemorrhage; **LOS,** length of stay; **MRFS,** Montebello Rehabilitation Factor Score; **mRS,** Modified Rankin Scale; **OA,** osteoarthritis; PCA, posterior cerebral artery; **PSUI,** post-stroke urinary incontinence; **QOL,** quality of life; **RA,** rheumatoid arthritis; **RMI,** Rivermead Mobility Index; **SDB,** sleep-disordered breathing; **SGA,** subjective global assessment; **SLE,** systemic lupus erythematosus; **UDSMR,** Uniform Data System for Medical Rehabilitation.

I. INTRODUCTION

Stroke occurs when neurologic deficits result after cerebral circulation is disturbed.[1] There are different etiologies for this phenomenon that may aid in our understanding of pathophysiology and lead to evidence-based improvements in the care of patients undergoing inpatient rehabilitation after stroke. Approximately 85% of strokes in the United States are ischemic, whereby atherosclerosis or thromboembolism result in reduced blood

0896-2960/13/$35.00

flow. Causes include cardiac embolism, large-artery disease, and small-artery disease. Approximately 15% of strokes in the United States are hemorrhagic, whereby blood at arterial pressure escapes from an artery into the cranium, causing injury by virtue of the high-pressure insult as well as the loss of cerebral blood flow. The mortality rate from acute hemorrhagic stroke remains between 40% and 50% in the United States. The 2 main types of hemorrhagic stroke are intracerebral hemorrhage, such as those due to lifelong untreated hypertension, and subarachnoid hemorrhage, such as those due to a ruptured berry aneurysm.[1–3]

A major goal in the care of patients who recently had a stroke is secondary prevention with a particular emphasis on limiting the risk factors related to stroke recurrence.[4] In addition to medications such as antiplatelet agents, risk factors can be modified, some of which include smoking, alcohol consumption, obesity, hypertension, and diabetes. Smoking can increase fibrinogen activation, which may cause thrombus formation in patients with atherothrombotic large-vessel disease. It also causes vasoconstriction, which further narrows penetrating intracranial arteries that already suffer from stenosis.[5] The relationship between alcohol consumption and ischemic stroke is one in which moderate drinkers (<24 g/day) have the lowest risk, whereas abstainers and heavy drinkers (>60 g/day) have the highest risk.[5] Obesity as a risk factor for cerebrovascular disease is not well established, but studies have shown that increased body mass index is not associated with increased stroke, but increased abdominal obesity or waist-to-hip ratio is. This relationship is more pronounced for ischemic than hemorrhagic stroke.[5–7] Hypertension is one of the strongest risk factors for stroke, and it is stronger for intracerebral hemorrhagic stroke than for ischemic stroke.[6] Treatment with antihypertensive medications significantly reduces the risk of stroke, myocardial infarction, and total vascular events in patients with cerebrovascular disease of any origin, regardless of baseline blood pressure levels.[5] Similar to this, diabetes has been found to increase the relative risk of stroke, particularly ischemic stroke, from 1.5 to 3.[7] Unfortunately, there are some nonmodifiable risk factors for stroke, including increased mortality with increasing age,[7] sex (men greater than women[7]), and race (African American[7]).

Another major goal in the care of a patient with recent stroke is to maximize function. Physical medicine and rehabilitation is a field that aims to restore functional ability in those with disabilities. Stroke rehabilitation in the United States generally consists of a multidisciplinary approach, including a physician, nurse, physical and occupational therapist, speech therapist, social worker, and case manager. Techniques used to restore function are broad and include range of motion exercises, strengthening of both weak and intact muscles, transfer training, gait training, the use of assistive devices, environmental modification, and speech and language exercises, all of which are geared toward promoting functional gains, including activities of daily living (ADLs), and preventing further disability. Some relatively newer modalities used are constraint-induced movement therapy, body weight–supported gait training, functional electrical stimulation, and robotic-assisted therapies.[8] Motor impairments traditionally have been the focus of therapeutic interventions. However, evidence is emerging that the treatment of "neglected

impairments" such as hemianopia, sensory loss, and spatial neglect, among others, plays a role in the patient's outcome.

The main goal of this article is to review the recent literature (within the past decade) on prognostic indicators of stroke and make recommendations that may serve to maximize the beneficial outcome following acute rehabilitation after stroke.

II. WHAT DEFINES A GOOD OUTCOME FOLLOWING STROKE?

An important question to consider when attempting to examine good prognostic indicators of stroke outcome is to determine what defines a good stroke outcome. Some of the most commonly used outcome measures are the Functional Independence Measure (FIM), the Modified Rankin Scale (mRS), the Barthel Index (BI), and discharge disposition. These measures are easily attainable, widely accepted, and relatively simple to perform. The FIM consists of 18 items that assess the patient's degree of disability and burden of care. Motor disability comprises 13 items and cognitive disability the other 5 items. Each item is rated on a 7-point scale, with 1 representing total assist and 7 representing complete independence. The highest attainable score is 126. Common measures obtained are the FIM score at admission, FIM score at discharge, and change in FIM from admission to discharge. The FIM instrument has been established as being valid and reliable and has a high sensitivity for measuring functional ability.[9] The BI is a tool used to measure functional ability and consists of 10 items testing mobility, ADLs, and bowel and bladder function. Scores range from 0 to 100, with a higher score indicating higher functional ability. The mRS is a scale from 0 to 6 that measures the level of a patient's disability. A variety of other outcome measures can be used, such as hospital readmission rates; complications attributed to the stroke, such as bowel or bladder incontinence; and related infection and mortality.

Many other factors besides functional ability might be considered important for defining a good outcome after a stroke. Those other factors are more difficult to ascertain but are certainly associated with quality of life (QOL). Examples include emotional health, depression, social involvement, work satisfaction, and family or social support.[9–15] The list of components that contribute to a good QOL are limitless. QOL is a multidimensional concept that has different meaning to different individuals, not to mention people from different cultures. Two individuals with very similar functional abilities are unlikely to claim similar satisfaction in life without taking into account psychosocial and emotional well-being. There are indices to measure some of these psychosocial components, such as the Beck Depression Index (BDI). However, the BDI relies on self-report and so may be vulnerable to under-reporting and over-reporting. In addition, certain stroke deficits may hinder self-reporting, such as aphasia, spatial neglect, deficits in magnitude estimation, pathological alteration of self-awareness, and alteration in distributed cortical systems supporting emotional semantics and abstraction.[16]

Defining and measuring QOL is a challenging task. de Haan et al.[17] suggested empowering the patient and directly asking the question, "How would you rate your present quality of life?" However, this single measure has little analytical value. The authors

further suggested that physical, functional, psychological, and social health are, at a minimum, the 4 dimensions that should be included when assessing QOL. They reviewed 10 QOL instruments and determined that existing QOL measures should undergo further psychometric evaluation rather than develop new instruments.

III. METHODS

A literature review was performed using searches of PubMed, Medline, and Google Scholar, as well as selected secondary references. Target articles for analysis were published within the past 10 years and pertained to stroke rehabilitation outcome and prognostic indicators. Keywords and phrases used to identify such articles included combinations of *stroke*, *CVA*, *outcome*, *prognosis*, *function*, *rehabilitation*, *discharge*, *demographic*, *age*, *education*, *race*, *ethnicity*, *sex, gender*, *ischemic*, *hemorrhagic*, *ICH*, *type*, *location*, *imaging*, *MRI*, *DTI*, *PET*, *EEG, TMS*, *neurological deficits*, *urinary incontinence*, *aphasia*, *infection*, *dysphagia*, *depression*, *comorbidities*, *diabetes*, *obesity*, *malnutrition*, *rheumatoid arthritis*, *osteoarthritis*, *mental health*, *depression*, *anxiety*, *obstructive sleep apnea*, *initial*, *quality of life*, and *social support*. Articles found in the references of articles and "similar articles" lists also were reviewed. A total of 29 journal articles were identified and reviewed (described later). Additional references were used to complement the knowledgebase gathered for this article.

IV. PROGNOSTIC FACTORS FOR STROKE REHABILITATION

A. Demographics

1. Age

A total of 5 studies with age as the prognostic factor were available, and all reports provided strong evidence that younger age is associated with a better outcome after stroke rehabilitation. Three of these studies were retrospective analyses[10,18,19] and 2 were multicenter prospective studies.[20,21] Two of the studies were performed outside the United States.[10,21]

In the multicenter study by Ostwald et al.,[20] 97 stroke survivors were tested immediately before and after discharge from inpatient rehabilitation hospitals to a spousal caregiver, using the National Institutes of Health Stroke Scale, FIM, Stroke Impact Scale, Geriatric Depression Scale-15, Perceived Stress Scale, and perceived health status. Older age was found to be significantly associated with less functional independence. That subjects were recruited across 5 different hospital systems is a feature that suggests results can be generalized across inpatient rehabilitation centers. A weakness of the study is that overall patient outcomes were not good: only a single subject showed independence after rehabilitation.

In a multicenter prospective cohort study conducted by Denti et al.[21] in Italy, 359 patients with first stroke and age >75 years were analyzed before and after undergoing a comprehensive medical rehabilitation program. Primary outcomes were frequency of discharge to home versus to a residential community and the extent of functional recovery, assessed by FIM score and the Montebello Rehabilitation Factor Score (MRFS) efficacy.

Age was found to be significantly related to FIM score at discharge and independently and inversely related to rehabilitation efficacy (MRFS). However, age did not show a significant relationship with discharge home. This large, multisite study draws strength from its large enrollment across 18 sites; however, the extent to which these results generalize to other populations, such as the general US population, remains uncertain.

A retrospective study by Pohl et al.[18] analyzed the records from the Allied Health Research Institute in Kansas, extracting demographic data and FIM scores for 31,910 adults who had been admitted for inpatient rehabilitation after stroke. Outcome measures included discharge to home versus residential care. Older age was found to be significantly associated with discharge to residential care. The mean age in the study was 77.7 years; patients older than this were found to be 1.6 times more likely to be discharged to residential care. The retrospective nature of this study and the use of rather broad entry criteria—for example, including only patients who have a complete medical record, age older than 65, and any stroke-related diagnosis—introduces an ascertainment bias and so limits the extension of these results with respect to a number of covariates of interest, such as aphasia, dysphagia, previous stroke, previous cognitive or independence level, radiological measures, socioeconomic factors, and psychological variables.[18]

A retrospective analysis by Kelly et al.[19] examined 1064 cases over a 4-year period from the hospital admissions and billing databases of Spaulding Rehabilitation Hospital in Boston, MA. This included patients with hemorrhagic and ischemic strokes. Motor and cognitive FIM scores were obtained at admission to and discharge from the hospital, and age was analyzed in relation to change in FIM scores and to total discharge FIM scores. Younger age independently predicted higher FIM scores in both categories for both ischemic and hemorrhagic stroke groups. The authors also reported that in patients with hemorrhagic stroke, greater functional impairment was present at admission to inpatient rehabilitation compared to patients with ischemic stroke, and that the hemorrhagic stroke group made greater gains and had FIM scores at discharge similar to those of the ischemic group. Although the study had well-defined inclusion and exclusion criteria, reports of each case relied on reviews of the medical record, and only one rehabilitation hospital system was analyzed, potentially limiting the generalization of results. Also, the study did not differentiate between patients in whom the index stroke was the first stroke versus a recurrent stroke, and furthermore included patients who had been transferred outside of the rehabilitation facility because of medical complications then readmitted. Nonetheless, a large number of cases was evaluated, and medical record review focused on objective data such as FIM scores and medical imaging. As such, it still provides useful evidence that younger age predicts a better outcome following acute rehabilitation after stroke.[19]

In a retrospective analysis by Mutai et al.,[10] records of 174 patients with stroke who were admitted to the convalescent rehabilitation ward at the Azumino Red Cross Hospital in Japan were analyzed for FIM and MRFS scores at discharge. Using multivariate stepwise analysis, age was found to be inversely related to both of these outcome measures. As with the above study by Denti et al.,[21] application of this study to US practice may be limited; however, this study does lend support to the general observation that in multiple

countries across the world age is a significant predictor of outcome in patients with stroke who have undergone inpatient rehabilitation.[10]

2. Race

Moderate, albeit inconsistent, evidence supports the hypothesis that race and ethnicity affect functional outcome. In terms of influencing hospital readmission rates, the evidence linking race is weaker. Of the 3 studies that were reviewed, 2 were retrospective[22,23] and the third was a prospective cohort study.[11] One study found that non-Hispanic white patients had better functional outcomes compared to subjects classified as a minority, and a second study found no difference in outcome related to race/ethnicity.

In a retrospective analysis, Ottenbacher et al.,[22] found that differences in ethnicity/race correlated with changes in functional status after stroke. Functional status was defined 3 ways (FIM at admission, FIM at discharge, and FIM efficiency), and race/ethnicity was classified as non-Hispanic white, black, Hispanic, and other. For all 3 endpoints, non-Hispanic whites had higher values, suggesting better outcomes. This remained true after adjusting for multiple variables including age, sex, Medicaid status, length of stay (LOS), marital status, type of stroke, and comorbidities. A strength of this study is its consistent documentation with the Uniform Data System for Medical Rehabilitation (UDSMR). Other strengths included sample size and restriction to sentinel strokes: a total of 161,692 patients with a first stroke received inpatient medical rehabilitation at one of >800 hospitals. This study also found that non-Hispanic whites were less likely to have Medicaid and more likely to be older.

Another study by Ottenbacher et al.[11] examined hospital readmissions in a prospective cohort of 674 subjects from the Stroke Underserved Populations Recovery Database. This study evaluated a broad population comprising patients ≥50 years old who received ≤50 days of inpatient rehabilitation after a first stroke at sites that were distributed across 8 states and the District of Columbia. Subjects were classified dichotomously, that is, as non-Hispanic white or minority. The primary outcome measure was rehospitalization within 3 months of discharge. Non-Hispanic white patients were again distinguished, here showing a higher likelihood of rehospitalization after stroke rehabilitation, although this finding did not remain significant after adjusting for motor functional status, depressive symptoms, and social support. It is interesting that the greater the number of symptoms in minority patients, the *lower* the readmission rate. Findings in non-Hispanic white patients tended to be in the opposite direction, albeit in a restricted way: the greater the number of depression symptoms, the *higher* the readmission rate. A weakness of the study is that the reasons for readmission were not defined.[11]

In a retrospective analysis Chiou-Tan et al.[23] investigated 171 underinsured patients from the UDSMR database, a well-recognized database widely supported by rehabilitation investigators. The subject pool included men and women older than the age of 18 and of Hispanic, black, and white race/ethnicity who underwent treatment at an inpatient rehabilitation unit at a large, urban county hospital. The main outcome measures were FIM scores at admission and discharge, LOS, FIM gain (FIM score at discharge minus

FIM score at admission), FIM efficiency (FIM gain divided by LOS), and discharge disposition. Race/ethnicity was significantly related to FIM rating at admission, FIM gain, and FIM efficiency but not to FIM rating at discharge or LOS. Hispanics had lower FIM scores at admission and greater FIM gains than blacks. However, there were no significant differences between these groups for FIM gain or FIM efficiency. Discharge disposition did not vary in relation to race/ethnicity, sex, or side or type of stroke. Although the study was retrospective in nature, it had strengths that included the use of well-defined objective criteria and inclusion/exclusion criteria. In addition, the index stroke was the first stroke for all study subjects.[23]

3. Sex

There is weak evidence that female patients are more likely to have a lower change in FIM score, lower FIM at discharge, and more likely to be discharged to residential living rather than home after undergoing acute rehabilitation for stroke. Of the 4 retrospective studies identified, one supports these sex-based findings for lower FIM,[9] 2 others provide supporting evidence in relation to discharge disposition,[10,18] and one showed no difference in discharge disposition according to sex.[23] The outcomes evaluated in these studies were secondary, however, and not primary.

A retrospective study by Ng et al.[9] showed that the female sex was associated with a lower change in FIM score and lower FIM at discharge. The study reviewed 89 patients with posterior cerebral artery strokes who were admitted to a dedicated stroke rehabilitation unit at Spaulding Rehabilitation Hospital. Outcome measures used were the discharge FIM instrument, total change in FIM score, FIM efficiency, and discharge to home. Weaknesses of the study include that it did not differentiate between ischemic and hemorrhagic strokes and the relatively small sample size. In support of these findings, other studies have reported similar results.

In the study by Mutai et al.,[10] a multivariate regression analysis revealed that female sex, living with family, premorbid disability, and neglect each were associated with a reduced probability of discharge to home. Similar to this, in the study by Pohl et al.,[18] more females were found to be discharged to residential care rather than home after inpatient rehabilitation following stroke. These results contrast with the findings of Chiou-Tan et al,[23] who found no difference in the distribution of discharge dispositions in relation to sex.

B. Stroke Characteristics

1. Stroke Type

There is strong evidence that patients with intracranial hemorrhage (ICH) have greater disability at admission to rehabilitation, but also make greater gains, compared to patients who have an ischemic stroke. This is supported by all 3 studies that were available for review: one being from the United States,[19] one from Australia,[24] and one from Italy.[25] However, conflicting evidence exists regarding the efficiency of rehabilitation in relation to stroke type.

A retrospective study by Kelly et al.[19] examined 1064 patients (871 with ischemic stroke and 193 with ICH) who had been admitted to the Spaulding Rehabilitation Hospital between 1996 and 1999. Clinical and demographic data and FIM scores were examined, as were stroke location and side. These authors found that, at admission, patients with ICH had significantly lower FIM scores and FIM cognitive subscores than patients with ischemic stroke, but no difference was found for FIM scores at discharge. The changes in total, motor, and cognitive FIM scores for patients with ICH were significantly greater than for patients with ischemic stroke. Kelly et al. also found that when comparing individual subjects with either ICH or ischemic stroke, patients with ICH and with the most severe strokes had significantly greater recovery compared with the ischemic subgroup. However, FIM efficiency was not found to be significantly different between the 2 groups. There was no statistically significant difference between patients who had supratentorial versus infratentorial lesions.

Katrak et al.[24] prospectively studied 718 patients with stroke (589 ischemic and 129 ICH) via a database of patients from the rehabilitation unit of Prince Henry Hospital and Prince of Wales Hospital in Australia. Similar to the study by Kelly et al.,[19] these authors also found that (1) the ICH group had lower FIM scores at admission compared to the ischemic stroke group; (2) no significant difference in cognitive, motor, or total discharge FIM scores existed between the ICH and ischemic group; and (3) greater gains in FIM score from admission to discharge were present in the ICH group compared to the ischemic group. In contrast to the study by Kelly et al., Katrak et al. did find a difference in FIM efficiency in relation to stroke type. They also analyzed changes in Motor Assessment Scale score, which were also greater in the ICH group. These results remained true when patient subgroups were analyzed, for example, examining only those patients with total anterior circulation syndrome, only those with partial anterior circulation syndrome, only those with posterior circulation syndrome, or only those with lacunar syndrome.[24] A strength of the study is the prospective generation of the database, which was nearly complete for each patient. This study is important in part because, coming from Australia, it confirms differences in rehabilitation outcomes between stroke across very different systems of care[24] compared to the study by Kelly et al.

Similar results were also obtained by Paolucci et al.[25] in a case control study of 270 inpatients with stroke (either ICH [n = 135] or ischemic stroke [n = 135]) at the University of Rome. These authors collected data on LOS, efficiency and effectiveness of treatment, and the percentage of low and high responding patients as determined by the BI, the Canadian Neurological Scale (CNS), and the Rivermead Mobility Index (RMI). Patients with ICH and ischemic stroke were matched at baseline by disability (BI score), stroke severity (CNS score), age, sex, and the interval between onset and admission. Although both ICH and ischemic stroke groups had made significant gains in CNS, BI, and RMI scores at discharge, the patients with ICH were found to have a significantly higher CNS and RMI scores. In addition, the patients with ICH, compared to the ischemic stroke group, were found to have (1) a higher effectiveness and efficiency on neurological, functional, and mobility status; (2) a higher percentage of high responders on the BI; and (3) a lower

percentage of persistent incontinence. Strengths of the study included blinding of raters and careful exclusion of those with transient ischemic attack, secondary hemorrhage, chronic disabling pathologies, trauma, or subarachnoid hemorrhage.[25]

2. Stroke Location

The retrospective study by Ng et al.[9] analyzed 89 patients with posterior cerebral artery (PCA) strokes who were admitted to a dedicated stroke rehabilitation unit at the Spaulding Rehabilitation Hospital. No significant differences were found in the FIM scores at admission or discharge when comparing patients with right- and left-sided PCA strokes. There was also no difference between superficial PCA (one or more cortical territories supplied by the PCA), superficial and deep PCA (involvement of deep/noncortical territories supplied by the PCA), and PCA plus (addition of territories not supplied by the PCA) stroke when comparing FIM at admission, FIM at discharge, change in FIM, or FIM efficiencies.

Another retrospective study by Ng et al.[26] studied the functional outcomes (FIM scores) of 2213 patients admitted to the Spaulding Rehabilitation Hospital Stroke Rehabilitation Unit with a first stroke in either anterior cerebral artery territory, middle cerebral artery territory, PCA territory, brain stem, cerebellar, or small-vessel territory or in more than one vascular territory. The data came from a prospective database over a 9-year period. These authors found that patients with a hemispheric (i.e., not cerebellar, brain stem, or small vessel) stroke had significantly lower FIM scores at admission, lower total FIM scores at discharge, and lower cognitive FIM scores at discharge compared to patients with cerebellar, brain stem, or small-vessel stroke. Patients with hemispheric stroke in the middle cerebral artery territory had the lowest FIM efficiency, and cerebellar strokes had the highest. All strokes had approximately equal and significant functional gains, however.[26]

Nazzal et al.[27] used a prospective, observational cohort study design to analyze outcome (a modified BI) in 111 patients with a first ischemic stroke who received treatment in the physical medicine and rehabilitation departments of 4 different hospitals. Patients were divided into 6 groups based on stroke location as determined from head computed tomography: (1) normal, (2) small superficial infarct, (3) large superficial infarct (infarcts on $\geq$2 lobes of one cerebral hemisphere), (4) deep infarct (internal capsule, basal ganglia, or thalamus), (5) combination of deep and large superficial infarcts, and (6) bi-hemispheric infarcts (at least one infarct in each cerebral hemisphere). The authors found that groups 4, 5, 2, and 3 showed the most improvement (in that order, from most improvement to least) and that groups 1 and 6 did not show significant change. Of note, patients in group 4 showed the greatest improvement in rehabilitation measures compared to the other groups. A weakness of the study was that the enrollment size was small, particularly given the number of groups. Strengths included using assessors who were blinded to radiological results, enrolling only patients with first stroke, excluding patients with posterior fossa infarcts, and including only those who were cognitively intact enough to follow commands and communicate and did not have any other central nervous system dysfunction.[27]

C. Neurological Deficit

Stroke can produce deficits in many different neurological domains. Some of these effects can have a direct impact on functional outcome, such as impaired gait or balance. Other effects can have a secondary influence on function, for example, when bowel/bladder incontinence results in a patient isolating himself from his peers. For a number of these neurological deficits, the effect on inpatient stroke rehabilitation has been studied.

1. Urinary Incontinence

There is strong evidence that post-stroke urinary incontinence (PSUI) has a negative impact on prognosis after stroke rehabilitation. For example, Turhan et al.[28] performed a retrospective study of 163 stroke patients looking at the relationship that age, sex, lesion location, recurrence of stroke, stroke etiology, and PSUI had on functional recovery. These authors found that PSUI negatively affected rehabilitation, defined as an FIM score of >80 at discharge. One interpretation of these findings is that the PSUI is a manifestation of multiple factors that may predict poor rehabilitation, such as poor cognition, severe cerebral involvement, autonomic nervous system problems, poor hygiene, ulcers, infections, malnutrition, older age, and lack of mobility.[28] In a retrospective study using data gathered from the National Stroke Audits in England, Wales, and Northern Ireland from 1998 to 2004, Wilson et al.[29] found that urinary incontinence is associated with higher levels of mortality, disability, and discharge to institutional care.

Urinary incontinence can arise from several different causes, an issue considered in a 2006 prospective observational study by Pettersen et al.[30] These authors evaluated 315 elderly patients with acute stroke, categorizing incontinence as either impaired awareness urinary incontinence or urge urinary incontinence. Of note, 147 of these patients had preexisting micturition disturbances. Outcomes measured were functional mobility, ADLs, and cognition. It was shown that impaired awareness urinary incontinence is an independent and strong risk factor for poor outcome 3 months after stroke.

Mizrahi et al.[31] retrospectively examined 919 consecutive patients with ischemic stroke who had been admitted to a geriatric rehabilitation department for rehabilitation. These authors studied the effects of bladder management, rather than incontinence on functional outcome, measured as total FIM at discharge and total change in FIM during admission. The level of bladder management was assessed using FIM scores, from 1 (total assist) to 7 (independence). The study found that when higher bladder management scores are present in elderly patients with ischemic stroke at admission, functional outcomes are statistically significantly better.

2. Aphasia

In a prospective observational study, Gialanella et al.[32] looked at the role of aphasia in predicting functional outcome, social outcome, and discharge destination after stroke. The investigation revealed that of 241 patients with a primary diagnosis of stroke, aphasia predicted lower motor FIM and cognitive FIM scores at admission and discharge. Aphasia

also predicted a poorer discharge destination, with more patients without aphasia being discharged home (77% vs. 91.6%). Aphasia is not a singular entity, and so Gialanella et al. further assessed whether a language examination, the Aachen Aphasia Test, could predict functional and motor outcome in patients with acute cerebrovascular accident of the left hemisphere who presented with aphasia. When multivariate regression analysis was performed, only final total FIM and cognitive FIM scores were predicted by comprehension of language; motor FIM score was predicted only by spontaneous speech. These observations strongly suggest that aphasia has a negative effect on prognosis.

D. Comorbidities

Although results vary across studies, overall evidence suggests that certain comorbidities have an effect on inpatient rehabilitation after stroke.

1. Diabetes

A retrospective analysis by Graham et al.[33] examined associations between diabetes mellitus and LOC, FIM score at discharge, and discharge setting in 135,097 patients treated across 864 inpatient rehabilitation facilities. These authors found that diabetes, based on Inpatient Rehabilitation Facility Prospective Payment System reimbursement rates, was significantly related to LOS, functional status, and discharge home. Younger diabetics had a shorter LOS, lower FIM score at discharge, and less discharge home, whereas older diabetics had a longer LOS and higher FIM score at discharge.

2. Malnutrition

An article from the FOOD (Feed Or Ordinary Food) trial collaboration[34] found that being undernourished immediately after stroke is associated with reduced survival, functional ability, and living circumstances 6 months after stroke. This association was less strong when adjusted for other variables, such as age, functional state before stroke, and stroke severity. Complications more commonly seen in the undernourished during their hospital admission included pneumonia, gastrointestinal bleeding, and other infections. This was found from 3 randomized controlled trials sharing the same randomization, data collection, and follow-up systems. The aim of the FOOD trial was to analyze different feeding policies of hospitals and compare outcomes of their hospitalized stroke patients.[34] Patients with a recent stroke (in the past 7 days) were categorized as undernourished, normal, or overweight by a randomizing physician on the basis of bedside assessment, weight, height, dietary history, and/or blood tests. Information was collected from patients at the 6-month follow-up by means of a questionnaire, telephone interview, or caregiver proxy. Patients' vital status, place of residence, and functional ability on the mRS were determined, and 3012 patients from 112 hospitals in 16 countries were included in the analysis. The study had the benefit of a large sample size from multiple centers, blinded researchers, and nearly complete follow-up. Unfortunately, the objectivity of the labeling of nutritional status is unclear.[34]

Similar findings were found by Davis et al.[35] Undernourished patients had greater mortality at 1 month and poorer outcome (defined as an mRS score ≤3) 30 days after stroke. However, poorer outcome also was associated with National Institute of Health Stroke Scale score, age, and premorbid mRS score. After adjusting for these factors, the relationship between poor outcome and undernourished patients was no longer statistically significant. The study reviewed the medical records or interviewed the next of kin of 185 patients within 24 hours of stroke. Nutrition was assessed by subjective global assessment (SGA), which determines nutritional status of the previous 6 months on the basis of a clinical evaluation of the patient's history and a physical examination. Like the FOOD trial,[34] this study was limited by the subjective nature by which undernutrition was defined.[35]

A more recent study by Pandian et al.[36] also found premorbid undernutrition to be associated with poor outcome after both univariate and multivariate analysis. The study took place in India; 448 patients with a first stroke were recruited from 6 major hospitals. Nutrition was assessed within 48 hours of stroke by an SGA completed by a dietician. The SGA normally rates patients as well nourished, moderately undernourished, and severely undernourished. However, this study combined moderately undernourished and severely undernourished into one group. Outcome was assessed using the mRS either at 1-month follow-up or over the telephone if the patient was unavailable for follow-up. Of the 448 patients, 326 were well nourished and 121 were undernourished. The study was limited by both the subjective nature of the SGA and the fact that the SGA was collapsed into 2 rather than 3 levels. The generalization of findings from this setting is also unclear. A strength of the study is the large sample size drawn from multiple centers.[36]

3. Rheumatoid Arthritis/Systemic Lupus Erythematosus

In a retrospective cohort analysis by Nguyen-Oghalai et al.,[37] patients with rheumatoid arthritis (RA) were found to have lower functional status at discharge from an inpatient rehabilitation unit than patients without RA or systemic lupus erythematosus (SLE) when the data were adjusted for FIM score at admission, although FIM scores at admission were similar. This remained the case when multivariate analysis adjusted for age, sex, race/ethnicity, type of stroke, LOS, and other comorbidities; it remained the case at 3 and 6 months of follow-up. The discharge disposition, however, was found to be similar in the 2 populations. On the other hand, SLE was not found to be associated with lower functional status at discharge or follow-up or with discharge disposition. The study looked at 47,853 patients from the UDSMR. Primary outcomes included discharge disposition (home vs. not home) and functional status at discharge, 3 months, and 6 months, as measured by the FIM. For analysis, the cohort was divided into 3 groups: 368 patients with RA, 119 patients with SLE, and patients with neither RA nor SLE. Although the UDSMR allows for control of multiple variables, it is dependent upon the Medicare patient population, which might represent a source of bias. An additional potential weakness is that this study did not include a measure of disease severity. However, the large sample size from multiple centers adds to the strength of the study.[37]

4. Osteoarthritis

In another retrospective cohort analysis by Nguyen-Oghalai et al.,[38] patients with stroke and with osteoarthritis (OA) were found to have a longer LOS than patients without a diagnosis of OA. While overall functional recovery during inpatient rehabilitation was similar, OA was associated with less continued progress of recovery rate after discharge. The authors used the UDSMR to investigate 3,094 patients with stroke and osteoarthritis and 44,943 with stroke without osteoarthritis from 744 hospitals in 48 states. Outcome variables measured were FIM scores at discharge and follow-up; rehabilitation gain (changes in FIM between admission, discharge, and follow-up); LOS; and rate of discharge home. They analyzed the data through multivariable linear regression analysis and verified it using 2 additional regression models. Weaknesses of the study include a lack of measure of the severity of OA as well as the retrospective design. A strength is the large sample.

5. Obstructive Sleep Apnea

In a prospective study from in China by Yan-fang and Yu-ping,[39] sleep-disordered breathing (SDB) was found to be associated with a worse functional outcome during early recovery from stroke. The study analyzed 60 patients who were in the acute stage after stroke at XuanWu hospital, 39 of whom had SDB diagnosed (via polysomnography). The Scandinavian Stroke Scale was used to assess neurologic severity at admission, with scores on the BI at 3 and 6 months after stroke onset used to assess functional outcome. SDB was associated with a poorer outcome at 3 months. Weaknesses of the study include the small sample size and lack of adjustment for other comorbidities. A strength was that patient evaluations were obtained while blinded to polysomnography results.

6. Infection

Infection after stroke is another complication that has been shown to be a strong indicator for an unfavorable prognosis after stroke. The 2 most common poststroke infections are pneumonia and urinary tract infections. In a prospective study, Kwan et al.[40] looked at predictors of stroke-associated infection and the associated effect of infection on 3-year survival rate. The study recruited 413 patients admitted to a stroke unit. Results showed that dysphagia and urinary incontinence at admission were independent risk factors for stroke-associated infection. It also was shown that mortality risk was significantly higher during the first year of follow-up after stroke when hospital-acquired infection was present. This risk was independent of initial ambulatory ability at admission, age, subtype of stroke, dysphagia, incontinence, mobility, and ability to talk.

E. Initial Functional Status After Stroke

There is strong evidence that functional status at admission to a rehabilitation unit is predictive of functional status at discharge. Four studies were uniform in reaching this conclusion.[9,10,19,21] There is, however, some evidence that function at admission does not predict the amount of recovery, although it can predict function at discharge.[19]

In the study by Kelly et al.,[19] in which a retrospective analysis was performed on 1064 stroke patients at the Spaulding Rehabilitation Hospital, a higher FIM cognitive score at admission was an independent predictor of total FIM score at discharge and change in total FIM scores in patients with ischemic stroke but not in those with ICH. Kelly et al. found that initial severity did not predict the amount of recovery, but it did independently predict functional status at discharge, for both ischemic and hemorrhagic stroke. The study was limited because of its retrospective nature and the inclusion of patients with multiple comorbidities, complications, and past strokes.

In a similar way, in the study by Denti et al.,[21] FIM score at admission independently predicted FIM and MRFS scores at discharge, with greater function at admission showing greater function at discharge. Premorbid Rankin score also was independently related to MRFS score. The study analyzed 359 patients with first stroke, >75 years old, before and after undergoing a comprehensive medical rehabilitation program. They also found that the score on the Mini-Mental Status Exam and the trunk control test each were independently related to functional recovery. As mentioned previously, although the study was prospective in nature, the extent to which results can be generalized is unclear.

In the study by Mutai et al.,[10] the single strongest predictor of FIM score at discharge in their subjects was FIM score at admission. Cognitive FIM at admission predicted MRFS and discharge FIM. Using FIM at discharge and MRFS as dependent variables, the study analyzed 174 stroke patients admitted to the convalescent rehabilitation ward at the Azumino Red Cross Hospital in Japan.

In the study by Ng et al.,[9] in which 89 patients with PCA strokes were admitted to a dedicated stroke rehabilitation unit at Spaulding Rehabilitation Hospital, lower total FIM score at admission was associated with lower FIM score at discharge.

F. Psychosocial Factors

A number of studies have assessed psychosocial factors and found many associations with stroke outcome. Key factors that influence stroke outcomes include depression,[11,12,14] social support,[9,11,13–15] and family involvement.[10,13] Patients with good social support and family involvement tend to have a favorable outcome following acute rehabilitation after stroke, whereas those with depression have worse outcomes.[9–11,13–15]

An observational study by Dossa et al.[12] found that in stroke victims, having 2 or more mental health conditions was associated with rehospitalization and death at 6 months compared with not having mental health conditions. Both depression and anxiety alone also were associated with increased rehospitalization and death at 6 months in stroke victims. The study analyzed 2162 patients with stroke who underwent inpatient rehabilitation at a Department of Veterans Affairs medical center. The 3 outcome measures were 6-month rehospitalization/death, mortality, and change in functional outcome, as measured by the FIM score. Mental health conditions were broken into several categories, including depression, anxiety, psychosis, and substance abuse. A weakness of the study is the lack of consideration given to certain comorbidities or socioeconomic factors.

In a multicenter prospective cohort study, Denti et al.[13] looked at outcome predictors

for stroke rehabilitation in the elderly. The 359 participants were >75 years old and enrolled in inpatient comprehensive rehabilitation for first-time strokes. The primary outcome measures were frequency of discharge to home and functional recovery, as assessed by FIM and the MRFS. Age was found to be an independent negative predictor of functional recovery. However, FIM at admission was the most important predictor for functional recovery. Social issues, such as living with family before the stroke, and cognitive status were positive predictors for being discharged home.

Fróes et al.[14] evaluated factors involved in health-related QOL, as assessed by the Medical Outcomes 36-item Short-Form Health Survey, FIM, and BDI. The study revealed that an active social life was associated with a better health-related QOL, and the lowering of health-related QOL was most associated with depressive symptoms, which affected several other domains. These findings were echoed by Ottenbacher et al.,[11] who looked at hospital readmission within 3 months as an important quality indicator following acute inpatient rehabilitation. Three factors were found to be important predictors of hospital readmission, 2 of which were depressive symptoms and social support. Social support was assessed by the Duke Social Support ratings. Those who scored in the lowest level of social support were found to be 2 times more likely to be rehospitalized. The Center for Epidemiologic Studies-Depression scale was used to quantify depression, and those scoring ≥16 were found to be 80% more likely to be rehospitalized.[11]

In a retrospective study of 89 patients with PCA stroke who were admitted to a rehabilitation hospital over an 8-year period, Ng et al.[9] evaluated factors associated with functional change during rehabilitation, as assessed by the FIM, along with discharge disposition. Among several other findings, in this subset of patients the presence of a caregiver proved to be strongly associated with successful discharge home.

Mutai et al.[10] studied 174 stroke patients admitted to a convalescent rehabilitation ward after acute rehabilitation to determine the factors involved in functional recovery and discharge to home. Among the psychosocial factors, not living with family was negatively associated with discharge to home.

In a study using data from the cohort study EMMA (Study of Stroke Mortality and Morbidity), Fernandes et al.[15] evaluated functional dependence among ischemic stroke survivors, as measured by the Rankin Scale. Their findings were quite interesting; in their sample the most important risk factor for functional dependence was lower socio-economic status, as assessed by a lower level of education. Several explanations for this are possible, including decreased access to rehabilitation centers and compliance with treatment, among others.

V. DISCUSSION

Understanding the interaction of predictors of gains during inpatient rehabilitation after stroke can help to maximize individual patient outcomes during a stay in a acute rehabilitation unit. Some of these predictive factors are nonmodifiable, whereas others are often amenable to improved control by a medical team. Many variables spanning a wide range of measures are associated with outcome after inpatient stroke rehabilitation. This

review found strong evidence that (1) younger age is associated with a better outcome after stroke rehabilitation,[18,20,21] (2) patients with hemorrhagic stroke have poorer baseline function but make greater gains compared to patients with ischemic stroke,[19,24,25] (3) an association exists between malnourishment and poorer outcomes,[34–36] and (4) living with family before a stroke or the presence of a caregiver predicts a higher likelihood of discharge to home.[9,10,13] There is also strong evidence that urinary incontinence,[28–31] infection after stroke,[40] and aphasia[32] negatively affect prognosis after stroke. Additional evidence strongly suggests that functional status at admission to a rehabilitation institute is predictive of functional status at discharge,[9,10,19,21]

There is moderate evidence that race and ethnicity affect functional outcome.[11,22,23] It also was observed that OA worsens recovery after stroke.[39] Furthermore, having an active social life is associated with a healthier QOL after undergoing stroke rehabilitation,[11,14] and a low educational level is an important factor for determining functional independence.[15]

Some evidence also exists that medical comorbidities can influence the extent of gains during an inpatient rehabilitation admission for patients after stroke. Diabetes,[33] RA,[37] OA,[38] or ≥2 mental health disorders (depression, anxiety)[12] in stroke patients are associated with increased rehospitalization and worse outcomes.

Imaging tools for evaluating the extent of damage to grey matter may be useful to assess outcomes. A number of measures of injury, such as motor evoked responses by transcranial magnetic stimulation– or magnetic resonance imaging–based measures of corticospinal tract damage, have been found useful for predicting spontaneous recovery from the early acute phase after stroke or response to therapy in the chronic phase of stroke.[41] Future studies can examine the utility of these measures as specific predictors of subacute response to inpatient rehabilitation therapy after stroke. In addition, by measuring extent of stroke-related neural injury, we can begin examining whether functional outcomes in patients admitted to an acute inpatient rehabilitation program after a stroke vary in relation to specific sites of brain infarct.[9,26,27]

On the basis of the evidence found within the past decade, the following recommendations can be made for clinicians and ancillary staff who are involved in patient care after stroke in an acute rehabilitation facilities. We should be aware that patients who are older, live alone, and have poor social support, multiple comorbidities, communication limitations secondary to stroke, and lower functional ability at admission may have poorer functional status at discharge. Physicians should be diligent in preventing malnourishment, treating infection after stroke, treating OA, and evaluating and treating urinary incontinence. Finally, additional prospective studies are needed with the primary aim of measuring the influence that key variables have on prognosis while controlling for the influence of other covariates.

VI. CONCLUSION

In this review we have attempted to summarize key predictors of rehabilitation outcomes after stroke while highlighting the strengths and weaknesses of many of the studies in an attempt to provide recommendations for providers of rehabilitation care after stroke.

In an effort to improve both the care of patients and the literature, we believe that this is attainable with by focusing on changing known modifiable risk factors, such as nutritional status, and treating certain modifiable health conditions. For nonmodifiable risk factors, the knowledge of a potentially poorer outcome may help in designing a more appropriate discharge plan. In the end, further research should be invested in designing prospective, randomized, controlled studies to ascertain the relationship of factors in predicting positive gains during a patient's stay in an acute rehabilitation unit after stroke.

REFERENCES

1. Lansberg MG, O'Donnell MJ, Khatri P, Lang ES, Nguyen-Huynh MN, Schwartz NE, Sonnenberg FA, Schulman S, Vandvik PO, Spencer FA, Alonso-Coello P, Guyatt GH, Akl EA; American College of Chest Physicians. Antithrombotic and thrombolytic therapy for ischemic stroke: antithrombotic therapy and prevention of thrombosis, 9th ed: American college of chest physicians evidence-based clinical practice guidelines. Chest. 2012;141(2 Suppl):e601S–36S.
2. Adams HP Jr, del Zoppo G, Alberts MJ, Bhatt DL, Brass L, Furlan A, Grubb RL, Higashida RT, Jauch EC, Kidwell C, Lyden PD, Morgenstern LB, Qureshi AI, Rosenwasser RH, Scott PA, Wijdicks EF. Guidelines for the early management of adults with ischemic stroke: a guideline from the American Heart Association/American Stroke Association Stroke Council, Clinical Cardiology Council, Cardiovascular Radiology and Intervention Council, and the Atherosclerotic Peripheral Vascular Disease and Quality of Care Outcomes in Research Interdisciplinary Working Groups: The American Academy of Neurology affirms the value of this guideline as an educational tool for neurologists. Circulation. 2007;115:e478–534.
3. Morgenstern LB, Hemphill JC 3rd, Anderson C, Becker K, Broderick JP, Connolly ES Jr, Greenberg SM, Huang JN, MacDonald RL, Messe SR, Mitchell PH, Selim M, Tamargo RJ. Guidelines for the management of spontaneous intracerebral hemorrhage: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke. 2010;41:2108–29.
4. Furie KL, Kasner SE, Adams RJ, Albers GW, Bush RL, Fagan SC, Halperin JL, Johnston SC, Katzan I, Kernan WN, Mitchell PH, Ovbiagele B, Palesch YY, Sacco RL, Schwamm LH, Wassertheil-Smoller S, Turan TN, Wentworth D. Guidelines for the prevention of stroke in patients with stroke or transient ischemic attack: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. Stroke. 2011;42:227–76.
5. Kirshner HS. Differentiating ischemic stroke subtypes: risk factors and secondary prevention. J Neurol Sci 2009;279:1–8.
6. O'Donnell MJ, Rangarajan S, McQueen MJ, Yusuf S, Xavier D, Pais P, Lio L, Zhang H, Want X, Mondo C, Damasceno A, Lopez-Jaramilly P, Hankey GJ, Dans AL, Yusoff K, Truelsen T, Diener H, Weirnar C. Risk factors for ischaemic and intracerebral haemorrhagic stroke in 22 countries (the INTERSTROKE study): a case-control study. Lancet 2010;376:112–23.
7. Allen C, Bayraktutan U. Risk factors for ischaemic stroke. Int J Stroke 2008;3:105–16.
8. Ifejika-Jones NL, Barrett AM. Rehabilitation–emerging technologies, innovative therapies, and future objectives. Neurotherapeutics. 2011;8:452–62.
9. Ng YS, Stein J, Salles SS, Black-Schaffer RM. Clinical characteristics and

rehabilitation outcomes of patients with posterior cerebral artery stroke. Arch Phys Med Rehabil 2005;86:2138–43.
10. Mutai H, Furukawa T, Araki K, Misawa K. Hanihara T. Factors associated with functional recovery and home discharge in stroke patients admitted to a convalescent rehabilitation ward. Geriatr Gerontol Int. 2012;12(2):215–22.
11. Ottenbacher KJ, Graham JE, Ottenbacher AJ, Lee J, Al Snih S, Karmarkar A, Reistetter T, Ostir GV. Hospital readmission in persons with stroke following postacute inpatient rehabilitation. J Gerontol A Biol Sci Med Sci. 2012;67:875–81.
12. Dossa A, Glickman ME, Berlowitz D. Association between mental health conditions and rehospitalization, mortality, and functional outcomes in patients with stroke following inpatient rehabilitation. BMC Health Serv Res. 2011;11:311.
13. Denti L, Agosti M, Franceschini M. Outcome predictors of rehabilitation for first stroke in the elderly. Eur J Phys Rehabil Med. 2008;44:3–11.
14. Fróes KS, Valdés MT, Lopes D De P, Silva CE. Factors associated with health-related quality of life for adults with stroke sequelae. Arq Neuropsiquiatr. 2011;69(2B):371–6.
15. Fernandes TG, Goular AC, Santos-Junior WR, Alencar AP, Bensenor IM, Lotufo PA. Educational levels and the functional dependence of ischemic stroke survivors. Cad Saude Publica. 2012;28:1581–90.
16. Barrett AM. Rose-colored answers: neuropsychological deficits and patient-reported outcomes after stroke. Behav Neurol 2010;22(1–2):17–23.
17. de Haan R, Aaronson N, Limburg M, Hewer RL, Van Crevel H. Measuring quality of life in stroke. Stroke. 1993;24:320–7.
18. Pohl PS, Billinger S, Lentz, A, Gajewski B. The role of patient demographics and clinical presentation in predicting discharge placement after inpatient stroke rehabilitation: analysis of a large, US data base. Diabil Rehabil 2013;35:990–4.
19. Kelly PJ, Furie KL, Shafqat S, Rallis N, Chang Y, Stein J. Functional recovery following rehabilitation after hemorrhagic and ischemic stroke. Arch Phys Med Rehabil. 2003;84:968–72.
20. Ostwald SK, Swank PR, Khan MM. Predictors of functional independence and stress level of stroke survivors at discharge from inpatient rehabilitation. J Cardiovasc Nurs. 2008;23:371–7.
21. Denti L, Agosti M, Franceschini M. Outcome predictors of rehabilitation for first stroke in the elderly. Eur J Phys Rehabil Med. 2008;44:3–11.
22. Ottenbacher K, Campbell J, Kuo YF, Deutsch A, Ostir G, Granger C. Racial and ethnic differences in postacute rehabilitation outcomes after stroke in the United States. Stroke. 2008;39:1514–9.
23. Chiou-Tan FY, Keng MJ, Graves DE, Chan KT, Rintala DH. Racial/ethnic differences in FIM scores and length of stay for underinsured patients undergoing stroke inpatient rehabilitation. Am J Phys Med Rehabil. 2006;85:415–23.
24. Katrak PH, Black D, Peeva V. Do stroke patients with intracerebral hemorrhage have a better functional outcome than patients with cerebral infarction? PM R. 2009;1:427–33.
25. Paolucci S, Antonucci G, Grasso MG, Bragoni M, Coiro P, Angelis D, Fusco FR, Morelli D, Venturiero V, Troisi E, Pratesi L. Functional outcome of ischemic and hemorrhagic stroke patients after inpatient rehabilitation: a matched comparison. Stroke. 2003;34:2861–5.
26. Ng YS, Stein J, Ning M, Black-Schaffer RM. Comparison of clinical characteristics and functional outcomes of ischemic stroke in different vascular territories. Stroke. 2007;38:2309–14.

27. Nazzal ME, Saadah MA, Saadah LM, Trebinjac SM. Acute ischemic stroke: relationship of brain lesion location and functional outcome. Disabil Rehabil. 2009;31:1501–6.
28. Turhan N, Atalay A, Atabek HK. Impact of stroke etiology, lesion location and aging on post-stroke urinary incontinence as a predictor of functional recovery. Int J Rehabil Res. 2006;29:335–8.
29. Wilson D, Lowe D, Hoffman A, Rudd A, Wagg A. Urinary incontinence in stroke: results from the UK National Sentinel Audits of Stroke 1998–2004. Age Ageing. 2008;37:542–6.
30. Pettersen R, Wyller TB. Prognostic significance of micturition disturbances after acute stroke. J Am Geriatr Soc. 2006;54:1878–84.
31. Mizrahi EH, Waitzman A, Arad M, Blumstein T, Adunksy A. Bladder management and the functional outcome of elderly ischemic stroke patients. Arch Gerontol Geriatr. 2011;53:e125–8.
32. Gialanella B, Santoro R, Ferlucci C. Predicting outcome after stroke: the role of basic activities of daily living. Eur J Phys Rehabil Med. 2012;48:1–2.
33. Graham JE, Ripsin C, Deutsch A, Kuo YF, Markello S, Granger CV, Ottenbacher KJ. Relationship between diabetes codes that affect medicare reimbursement (tier comorbidities) and outcomes in stroke rehabilitation. Arch Phys Med Rehabil. 2009;90:1110–6.
34. FOOD Trial Collaboration. Poor nutritional status on admission predicts poor outcomes after stroke: observational data from the FOOD trial. Stroke. 2003;34:1450–6.
35. Davis JP, Wong AA, Schluter PJ, Henderson RD, O'Sullivan JD, Read SJ. Impact of premorbid undernutrition on outcome in stroke patients. Stroke. 2004;35:1930–4.
36. Pandian JD, Jyotsna R, Singh R, Sylaja PN, Vijaya P, Padma MV, Venkateswaralu K, Sukumaran S, Radhakrishnan K, Sarma PS, Mathew R, Singh Y. Premorbid nutrition and short term outcome of stroke: a multicentre study from India. J Neurol Neurosurg Psychiatry. 2011;82:1087–92.
37. Nguyen-Oghalai TU, Wu H, Mcnearney TA, Granger CV, Ottenbacher KJ. Functional outcome after stroke in patients with rheumatoid arthritis and systemic lupus erythematosus. Arthritis Rheum. 2008;59:984–8.
38. Nguyen-Oghalai TU, Ottenbacher KJ, Granger CV, Goodwin JS. Impact of osteoarthritis on the rehabilitation of patients following a stroke. Arthritis Rheum. 2005;53:383–7.
39. Yan-fang S, Yu-ping W. Sleep-disordered breathing: impact on functional outcome of ischemic stroke patients. Sleep Med. 2009;10:717–9.
40. Kwan J, Pickering RM, Kunkel D, Fitton C, Jenkinson D, Perry VH, Ashburn AM. Impact of stroke-associated infection on long-term survival: a cohort study. J Neurol Neurosurg Psychiatry. 2013;84:297–304.
41. Burke E, Cramer SC. Biomarkers and predictors of restorative therapy effects after stroke. Curr Neurol Neurosci Rep. 2013;13:329.